
2. Recreational Fishing

2.1 Introduction

In this chapter, damages from lost recreational fishing services caused by PCB releases to the Kalamazoo River are quantified. As discussed in Chapter 1, recreational fishing damages constitute an important component of damages, but they are only one component of compensable values for service losses (see Table 1.1). The Stage I Assessment focuses on recreational fishing damages because this component is likely to be a significant portion of the total sum of compensable values and because relatively reliable estimates of this damage category can be readily developed from existing information supplemented with additional site-specific studies. Nevertheless, the estimates reported in this chapter are underestimates of those total losses, because only one type of service loss is valued.

The calculation of recreational fishing damages is based on the following:

- ▶ Estimates of actual recreational fishing use on the Kalamazoo River with FCAs in effect. These estimates, described in Section 2.4, were developed primarily from a 1985-1987 Kalamazoo River creel survey by the MDNR and the results of a survey of recreational fishing use, termed the KRRRA study, which was conducted by the Trustees in 2001 as part of the Stage I Assessment (see Appendix B).
- ▶ Estimates of recreational fishing use on the Kalamazoo River and in Lake Michigan that would have existed if PCBs had not been released and FCAs were not in effect (i.e., fishing use under baseline conditions). These estimates were developed from a combination of the literature on behavioral responses to FCAs and other site characteristics, the results of a Kalamazoo River area survey conducted by the PRPs, a recreational fishing demand model created by researchers at MSU, and a comparison to recreational fishing use on the nearby (and less contaminated) St. Joseph River (Section 2.5).
- ▶ The value of the reduced quality of current recreational fishing and the reduced number of recreational fishing days due to PCB contamination and the FCAs. The estimated values of the reduction in fishing days and in fishing quality that result from the PCB FCAs were developed from the available literature.

Estimates of aggregate annual recreational fishing damages are then computed by multiplying the number of affected Kalamazoo River fishing days (encompassing both reduction in quantity and quality) by the corresponding economic value associated with the effect.

2.2 Kalamazoo River Target Species and Fish Consumption Advisories

The deinking, repulping, and use of recycled paper stock led to PCB releases into the Kalamazoo River. An estimated 2.2 to 4.4 million pounds of PCBs were released into the Kalamazoo River (U.S. District Court, 2000).

Releases of PCBs into the Kalamazoo River have resulted in FCAs for the Kalamazoo River and have contributed to the need for FCAs in Lake Michigan. These advisories, which are produced by the Michigan Department of Community Health (MDCH)/MDNR (1977-2001), act as a guide to anglers by recommending how many fish may be eaten safely by the general population and by a special population defined as children and women who are pregnant, nursing, or expect to bear children.¹ These advisories vary by river location and type and size of fish. They include the species commonly sought in the Kalamazoo River (smallmouth bass, walleye, and northern pike) and Lake Michigan (salmon and lake trout). They are more restrictive upstream of Allegan Dam² than downstream of the dam (see Figure 2.1).

The central stretch of the Kalamazoo River from Morrow Lake Dam to Allegan Dam is a warm water fishery, and smallmouth bass are the primary target species (James Dexter, MDNR Fisheries Supervisor, personal communication, June 7, 2001). MDNR estimates that in this stretch, 80% of the recreational fishing effort is fishing for smallmouth bass, 15% is for walleye, and 5% is for northern pike (James Dexter, MDNR Fisheries Supervisor, personal communication, June 7, 2001). The KRRRA study surveyed 94 Kalamazoo River anglers, primarily between Morrow Lake Dam and Lake Michigan (see Figure 2.1), from May to December 2001 (see Appendix B for further discussion). In the KRRRA study, anglers were asked to name the species they were targeting. In this stretch, 11% said they were targeting bass; 22% perch, bluegill, or sunfish; 11% walleye or pike; 11% carp, catfish, or suckers; and 72% “whatever is biting” (percentages sum to more than 100% because anglers could be targeting more than one species). Of the large group who responded, “whatever is biting,” the majority in the central stretch were targeting and catching bass, so the breakdowns are roughly consistent across the two sources of data when “whatever is biting” is reallocated as bass.

1. From 1977 to 1983, children are not defined by age in the FCAs. From 1984 to 1987 the advice is for children age 6 and under, and from 1988 to 2000 the advice is for children age 15 and under.

2. Allegan Dam, also known as Caulkins Dam, is the dam that creates Lake Allegan, not to be confused with the dam upstream in the town of Allegan called Allegan City Dam.



Figure 2.1. Kalamazoo River and St. Joseph River.

Since 1979, smallmouth bass have had a “do not eat” restriction for all fish that meet the legal size limits in this stretch,³ with the exception of 1985-1989, when the smallmouth bass advice was “no more than one meal per week” for the general population and “do not eat” for the special population (of women and children). While smallmouth bass are the most targeted species in this stretch, all other sport species have FCAs as well. The restriction for the other sport species has been “no more than one meal per week” for the general population and “do not eat” for the special population from 1985 to the present. (Tables C.1 and C.2 in Appendix C show the exact advisories by species, size, location, and year for the Kalamazoo River and Lake Michigan.)

Like the central river stretch, the lower Kalamazoo River from Allegan Dam to Saugatuck supports a bass fishery. However this stretch is unique in that it also supports cold water species (trout and salmon). These salmonids enter the river from Lake Michigan to spawn in Kalamazoo tributaries such as the Rabbit River. This migration makes this stretch of river a very popular fishing site, particularly during spring and fall runs. MDNR estimates that in this stretch 60% of the recreational fishing effort is fishing for steelhead (rainbow trout), 20% is for salmon, 15% is for walleye, and 5% is for smallmouth bass (James Dexter, MDNR Fisheries Supervisor, personal communication, June 7, 2001). In the KRRRA study, 38% said they were targeting salmon; 3% trout; 7% bass; 16% perch, bluegill, or sunfish; 15% walleye or pike; 18% carp, catfish, or suckers; and 56% “whatever is biting” (percentages add to more than 100% because anglers could be targeting more than one species). Of the large group who responded, “whatever is biting,” the majority in the lower stretch were most likely targeting salmon and trout (most of these anglers were interviewed at Allegan Dam, where salmonids congregate), so the breakdowns are consistent across the two sources of data.⁴ Assuming all anglers who responded “whatever is biting” are fishing for salmonids, the total targeting these species (rather than warm water species) is 81%.

The FCA restrictions for the lower stretch from Allegan Dam to Saugatuck for warm water species are generally less stringent than those above the dam, with advice being “no more than one meal per week” for the general population and “do not eat” for the special population for legal-sized bass and northern pike. Advisories for salmonids (trout and salmon) for this stretch are the same as those for southern Lake Michigan (described below).

3. Recreational anglers may only keep fish above a certain length (the legal size limit) defined in the Michigan Fishing Regulations (MDNR, 1999). Therefore the FCAs do not give advice for fish smaller than the legal size limit.

4. This is a congested fishing site. If anglers want to target other species there are more convenient places, but if they prefer targeting salmon this is the optimal spot. This is corroborated by the in-field interviews for the KRRRA study.

PCBs released into the Kalamazoo River from paper company facilities have entered Lake Michigan and contribute to the total PCB loadings in Lake Michigan. Thus, a portion of fishing impacts and damages in Lake Michigan from PCB-caused FCAs are attributable to the Kalamazoo River. Lake Michigan advisories vary by species, size, and year, with larger fish having greater restrictions. In Lake Michigan the most important recreational fishing species are salmonids (coho and chinook salmon, and steelhead, brown, and lake trout); in the last 20 years, 80% to 90% of the hours spent in recreational fishing on Lake Michigan were spent targeting salmonids (Rakoczy and Svoboda, 1997). Data from this study on fishing effort by species are not available at the closest creel site to the Kalamazoo River (site 156 at Holland, which includes Saugatuck – see Figure 2.1), but the harvest of salmonids for Lake Michigan breaks down as 45% for coho and chinook salmon, 30% for lake and brown trout, and 25% for steelhead (Rakoczy and Svoboda, 1997, and data from personal communication with G. Rakoczy, MDNR, March 2001).

The advisories for Lake Michigan apply to the Kalamazoo River from Lake Michigan up to Allegan Dam. The Lake Michigan and lower Kalamazoo River advisories for salmonids have varied throughout the years, becoming less restrictive recently. Generally from 1977 to 1995, it was advised that the general population should eat no more than one meal of salmon per week, and that the special population should eat none. More recently this advice was relaxed to advise that the general population eat unlimited amounts and the special population restrict consumption to 6 to 12 meals a year. For lake and brown trout (larger than 23 inches for both species), advice has remained “do not eat” from 1986, when they were first added to the advisory, to the present, and advisories for those less than 23 inches are similar to those for salmon. Steelhead had an advisory from 1977 to 1985 (“no more than one meal a week” for the general population and “do not eat” for the special population) and 1998 to the present (“no more than one meal a week” for steelhead 10 to 18 inches or “no more than one meal a month” for steelhead greater than 18 inches for the special population).

2.3 Behavioral Responses to FCAs

The intent of FCAs is to educate and warn anglers about potential health risks associated with eating fish and to encourage changes in behavior, if and as necessary, to reduce potential health risks. The KRRRA study found that 41% of those fishing on the river were aware of FCAs. Most anglers did not eat any of the fish they caught there (72% of all anglers surveyed above Allegan Dam and 48% of all anglers surveyed below). When asked what they most disliked about fishing the Kalamazoo River, 9% said PCBs, although those continuing to fish the Kalamazoo River may be less concerned about the contamination than those who have substituted to other sites.

Another survey conducted in the assessment area (Atkin, 1995) was specifically of anglers who live in eight counties closest to the Kalamazoo River. Of the 690 anglers interviewed, 67% were aware of the FCAs issued by the Michigan Department of Public Health and 25% mentioned the Kalamazoo River specifically. The survey found that 38% of anglers aware of FCAs avoid fishing certain locations because of FCAs (those locations were not specified). These trips are substituted to other sites or activities that would be considered inferior if the Kalamazoo River were not contaminated. Anglers who fish elsewhere are incurring higher travel costs or inferior conditions (than they would enjoy under baseline conditions) because of the substitution. The Atkins study shows a strong response to FCAs, especially in terms of changing fishing location and avoiding fish from waters with FCAs. Other studies of other Great Lakes fishing sites confirm and show a broader picture of the significance of FCAs on angler behavior.

The literature on anglers' behavioral responses to FCAs repeatedly shows that anglers change their behavior in response to FCAs. Table 2.1 reports key results from this literature for Great Lakes locations. In each study the FCAs vary by fish species, and for the studies where more than one site is included, they also vary by location. The behavioral responses to FCAs range from reductions in trip taking to changes in how fish are prepared and cooked. These behavioral changes represent recreational fishing services that have been lost to anglers, so they experience damages. Even anglers who do not change their behavior may experience a reduction in enjoyment of their fishing experience, thus experiencing a loss of services, and therefore may be injured.

Table 2.1. Selected Great Lakes studies of behavioral responses by anglers to FCAs

Study	State, year	Site	Reported behavioral response to FCAs ^a
Atkin, 1995	MI, 1994	All sites in the 8 counties near the Kalamazoo River	Percent of all anglers (in parentheses, percent of anglers who were aware of or had heard of Michigan FCAs) 5% (7%) change type of fish targeted 29% (38%) avoid fishing certain locations 42% (55%) avoid eating all fish from advisory waters 7% (9%) avoid eating certain types of fish from advisory waters 8% (11%) reduced quantity of fish eaten from advisory waters 7% (9%) changed the way fish from these waters is cooked or trimmed
Breffle et al., 1999	WI, 1999	Lower Fox River and Green Bay	For active Lower Fox River/Green Bay anglers 30% spend fewer days fishing 31% change locations fished 23% target different species 45% change the species they keep to eat 47% change the size of fish they keep to eat 45% change the way they clean/prepare fish 25% change the way they cook fish

Table 2.1. Selected Great Lakes studies of behavioral responses by anglers to FCAs (cont.)

Study	State, year	Site	Reported behavioral response to FCAs ^a
Connelly et al., 1990	NY, 1987-1988	New York inland waters and Lake Ontario	Of the 82% aware of health advisories, 61% made a change; of these 61%: 17% take fewer trips 31% change fishing locations 46% change cleaning/cooking methods 51% eat fewer fish from the site 17% eat different species 11% no longer eat fish from the site
Connelly et al., 1992	NY, 1990-1991	All waters of New York	Of the 85% aware of advisories, 50% made a change; of these 50%: 18% take fewer trips 45% change cleaning methods 25% change the size of fish consumed 21% change cooking methods 70% eat less fish from the site 27% eat different species 17% no longer eat fish from the site
Connelly et al., 1996	NY, 1993	Fish caught in Lake Ontario	79% use risk-reducing cleaning methods 42% use risk-reducing cooking methods 32% would eat more fish in the absence of FCAs
Fiore et al., 1989	WI, 1985	Lake Michigan	57% report changing fishing habits and/or fish consumption habits
Hutchison, 1999	WI, 1997	Lower Fox River	64% had made a change; of these 64%: 71% travel to other locations to fish 66% do not eat the fish they catch 18% change frequency of fish consumption 10% target and catch different species 7% change the size of fish they keep 2% clean or prepare fish in different ways
Knuth, 1996	NY portion of Lake Ontario, 1993	Fish caught in Lake Ontario	75% refrain from consuming fish that advisories state should not be consumed 80% do not exceed advisory recommendations
Knuth et al., 1993	IL, IN, OH, KY, PA, WV, 1992	Fish caught in the Ohio River	Of the 83% aware of advisories: 37% take fewer trips 26% change fishing locations 26% change targeted species 23% change cleaning methods 17% change the size of fish consumed 13% change cooking methods 42% eat less fish from the site 13% no longer eat fish from the site

Table 2.1. Selected Great Lakes studies of behavioral responses by anglers to FCAs (cont.)

Study	State, year	Site	Reported behavioral response to FCAs ^a
Silverman, 1990	MI, 1990	All waters of Michigan, including Great Lakes and inland waters	Of the 54% who are aware of the advisories, 92% have modified their behavior; of these 92%: 10% take fewer trips 31% change fishing locations 21% change targeted species 56% change cleaning methods 41% change the size of fish consumed 28% change cooking methods 56% eat less fish from the site 31% eat different species
Vena, 1992	NY, 1990-1991	Fish caught in Lake Ontario	Of the 92% aware of the health advisory, 41% made changes; of these 41%: 16% take fewer trips 30% change fishing locations 20% change targeted species 31% change cleaning methods 53% eat less fish from the site 16% no longer eat fish from the site
West et al., 1989	MI, 1988	Michigan Great Lakes and inland waters	87% were aware of advisories; of these 87%: 76% change cleaning methods 73% change cooking methods 64% eat fewer fish from the site 66% change species fished
West et al., 1993	MI, 1991-1992	Michigan Great Lakes and inland waters	86% change cooking methods (Great Lakes anglers) 80% eat different species (Great Lakes anglers) 46% eat less fish from the site (overall) 27% change cooking methods (overall) 80% are aware of advisories; of these 80%: 75% change cleaning methods
a. Unless otherwise indicated, percentages are for all anglers, not just those aware of FCAs.			

The study results listed in Table 2.1 show a broad consistency in the types of behavioral changes, although the specific magnitude of responses to FCAs varies by location, FCA severity, and species.⁵ Many of the studies in Table 2.1 cannot be directly compared because some results are

5. Some studies interviewed people who continued to fish at a site, omitting anglers who moved to substitute sites, or interviewed only those anglers who continued to fish in a region, omitting anglers who stopped fishing the region (or potential new anglers who did not start fishing) because of FCAs. As a result, the statistics in Table 2.1 may understate the response of changing where one fishes as a result of the FCAs. Because the results of Table 2.1 are used, in part, to estimate substitution from the Kalamazoo River due to FCAs, use of these results contributes to conservative damage estimates.

reported as percentages of all anglers, some results are reported as percentages of anglers aware of FCAs, and some results are reported as percentages of anglers who are both aware of FCAs and have modified their behavior. The percentage of anglers who are aware of advisories may be directly affected by the population of anglers sampled. For example, awareness of the FCAs for the Kalamazoo River is expected to be much higher for anglers living in Allegan and Kalamazoo counties, where the assessment area is located, than the awareness of these specific FCAs of all Michigan anglers. Therefore, while the percentage of all anglers who have a behavioral response to FCAs can be computed by multiplying the percentage of knowledgeable anglers by the percent of those anglers who change their behavior, in general that is not done.⁶ Because the sampled populations vary widely across the studies, there are limitations to how these figures can be compared across studies for any specific behavioral change.

The literature cited in Table 2.1 suggests that the presence of FCAs has resulted in reductions to the number of recreational fishing days taken. Anglers who continue to fish the Kalamazoo River are also affected because the quality of fishing has been reduced. The presence of FCAs may also have discouraged some anglers from fishing at all. For some individuals, the Kalamazoo River may be the only site that they would like to fish because of the convenience of its location. These individuals may return to fishing in the absence of contamination and FCAs; therefore they have experienced service losses and will continue to experience losses until FCAs are removed because they are no longer necessary.

2.4 Estimates of Kalamazoo River Recreational Fishing Use

Sport fishing is a popular recreational activity in Michigan enjoyed by approximately 1.5 million anglers each year. In 1996, resident anglers took about 21 million fishing trips and nonresidents took about 1 million fishing trips in Michigan (U.S. DOI, 1998). The MDNR conducts creel surveys and counts of Michigan fishing activity annually for Lake Michigan and some other popular sites. MDNR surveyed the Kalamazoo River from 1985 to 1987, but has not done so since then. In 2001, the Trustees conducted a new count study and creel survey (the KRRRA study is described in detail in Appendix B). The 1985-1987 data and the KRRRA study were used to estimate use levels from 1981 to the present.⁷

6. The exception is in Section 2.5, where results from these studies are used loosely to infer the percentage of anglers who substitute to other fishing sites or reduce their total fishing days as a result of contamination.

7. Damages are estimated starting in 1981 because Section 107(f)(1) of CERCLA limits recovery for natural resource damages to cases where the damages and the release of hazardous substances from which such damages resulted have occurred wholly after the enactment of CERCLA on December 11, 1980.

Kalamazoo River

As discussed above, the Kalamazoo River includes two stretches that differ greatly in terms of the type of species sought. In the lower stretch, anglers target cold-water sport fish such as salmon and trout, and these fish are stocked by the state yearly (MDNR, 2000). Anglers can also catch walleye, smallmouth bass, bluegill, and catfish on this stretch. Using data from the Kalamazoo River Basin Fisheries Management Plan (Johnson et al., 1988), from the MDNR 1985, 1986, and 1987 creel surveys for the Kalamazoo River below Lake Allegan Dam, and from personal communication with James Dexter (MDNR Plainwell District, 1993) it is estimated that use levels for the lower stretch ranged from 48,600 to 56,200 fishing days per year in 1985 through 1987 (see Table 2.2).⁸ Each year the MDNR conducts creel surveys of inland waters using standard practices of data collection and aggregation methods as discussed in Lockwood (2000). However the Kalamazoo River was included in the yearly creel surveys only in 1985 through 1987. These creel data are the only aggregate use estimates for the Kalamazoo River available from 1985 to 2000 (the KRRRA study was conducted in 2001).

In 1994 the MDCH intercepted anglers on the Kalamazoo River to evaluate their exposure to PCBs, DDE, and mercury (MDCH, 2000). Of the 1,060 intercepted, 937 participated in their study. While the study found that Kalamazoo River fish-eaters were likely to have significantly higher residual levels of PCBs in their blood than non-fish-eaters, it did not use a sampling plan to contact anglers, or collect data in such a way that aggregate inferences could be made about use.

The KRRRA study estimates that there were 19,416 to 20,193 fishing days on the lower Kalamazoo in 2001.⁹ To extrapolate levels between 1987 and 2001, a linear change from the 1985 through 1987 levels to the 2001 levels is assumed for the lower stretch. This is shown in Table 2.2. For the years before 1985 it is assumed that use was constant at the 1985 through 1987 level.

8. If one angler fishes for any part of one day, that is an “angler day.”

9. These figures do not include winter fishing, which is expected to be relatively low. See Appendix B, Section B.5.

Table 2.2. Estimate of fishing days on the Kalamazoo River

Year	1985- 1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Central stretch: Morrow Lake Dam to Allegan Dam ^a	4,860 to 5,620	4,652 to 5,363	4,443 to 5,106	4,235 to 4,848	4,533 to 5,091	4,831 to 5,334	5,130 to 5,576	5,428 to 5,819	5,727 to 6,061	6,025 to 6,304	6,323 to 6,547	6,622 to 6,789	6,920 to 7,032	7,219 to 7,274	7,517 to 7,517
Lower stretch: Allegan Dam to Lake Michigan ^b	48,600 to 56,200	46,515 to 53,628	44,431 to 51,056	42,346 to 48,484	40,262 to 45,912	38,177 to 43,340	36,093 to 40,768	34,008 to 38,197	31,923 to 35,625	29,839 to 33,053	27,754 to 30,481	25,670 to 27,909	23,585 to 25,337	21,501 to 22,765	19,416 to 20,193
Total	53,460 to 61,820	51,167 to 58,991	48,874 to 56,162	46,581 to 53,333	44,795 to 51,003	43,009 to 48,674	41,222 to 46,345	39,436 to 44,015	37,650 to 41,686	35,864 to 39,357	34,078 to 37,027	32,292 to 34,698	30,505 to 32,369	28,719 to 30,039	26,933 to 27,710

a. Central stretch use is assumed to be 10% of lower stretch from 1985 to 1990 (from personal communication with James Dexter, MDNR, March 2001), and then is assumed to grow linearly from 1991 to 2001 (a straight line extrapolation between these two endpoints).

b. Lower stretch use is based on 1985-1987 average days for Kalamazoo (Johnson et al., 1988; and from personal communication with James Dexter, MDNR, 1993) with linear growth to the 2001 KRRRA estimates (a straight line extrapolation between these two endpoints).

A second-best alternative method of extrapolating the 1985 through 1987 estimates to recent years is to assume that the lower stretch of the Kalamazoo River experienced the same proportional fluctuations in fishing effort as the lower stretch of the nearby St. Joseph River (1985-1987 data are available only for the lower stretches). This method is used to provide additional evidence as groundtruthing for the primary estimate described above. The St. Joseph River can be used as a comparison for several reasons. It has had consistent creel fishing surveys conducted from 1985 to the present. The MDNR sampled the St. Joseph River using the same methods and in the same years (1985 through 1987) as the Kalamazoo River. It is proximate, lying about 48 miles south of the Kalamazoo River. It is also surrounded by a similar-sized population. The Kalamazoo River is closer to in-state population centers such as Kalamazoo, Grand Rapids, Muskegon, Detroit, and Lansing than the St. Joseph River, and the St. Joseph River is closer to Chicago, Illinois, and South Bend, Indiana. These rivers are of roughly similar size with the same species, both drain into Lake Michigan, and both are likely to have experienced about the same weather and climate conditions. Thus it is a similar site to approximate the fluctuations in fishing pressure that the Kalamazoo River most likely experienced.¹⁰ This approach may result in an underestimate of Kalamazoo fishing use since the counties near the Kalamazoo experienced an 11% increase in population from 1985 to 2000, whereas counties near the St. Joseph experienced no increase in population in this same period (U.S. Census Bureau, 2001). Table 2.3 shows the estimates using the St. Joseph River fishing growth for 1985 to 2000. Comparing this to the extrapolation using the creel data, there is a higher range of use levels. For damage calculations, the estimates based on the KRRRA survey (shown in Table 2.2) were used, since they are specifically for the assessment area.

The central stretch of the Kalamazoo River, from Morrow Lake Dam to Allegan Dam, receives only a fraction of the use of the lower stretch. It is a warm water fishery that is 49.2 river miles long. While this stretch is believed to be a productive fishery in terms of stock, restrictive FCAs placed on all species of all sizes (as discussed in Section 2.2) may be contributing to the lack of use of this stretch (James Dexter, MDNR, personal communication, March 2001). Use of the central stretch above Allegan Dam increased starting in the early 1990s largely as a result of improvements in the aesthetic quality of the river (James Dexter, MDNR, personal communication, March 2001). Although there continue to be problems with the river's appearance and odor, more anglers returned to the river in the early 1990s as water quality, odor, and appearance improved.

10. There are also several notable differences between the rivers, such as more wetlands and government-owned property surrounding the Kalamazoo River, and greater widths on the St. Joseph River that are more conducive to boating recreation (see Appendix F for further explanation).

Table 2.3. Second-best estimate of fishing days on the lower stretch of the Kalamazoo River (below Allegan Dam to Lake Michigan) based on St. Joseph River growth rate

	1985-1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Fishing days	48,600	41,771	41,771	30,797	30,685	40,059	28,853	41,175	38,953	44,115	43,435	29,645	45,622	43,703
	to	to	to	to	to	to	to	to	to	to	to	to	to	to
	56,200	48,303	48,303	35,613	35,483	46,323	33,366	47,614	45,045	51,013	50,227	34,280	52,756	50,537

Estimated using data from Kalamazoo River use in 1985-1987. Extrapolated to future years assuming the same fluctuations in fishing pressure as in the St. Joseph River use.

Sources: Johnson et al., 1988; and from personal communication with James Dexter, MDNR, 1993.

Data on aggregate use of the central stretch are available only for 2001 (KRRRA). For that reason, professional estimates of the level of use on the central stretch from James Dexter of the MDNR Plainwell office are used. James Dexter has worked in the Kalamazoo River area as a fisheries biologist since the 1980s. He was involved in conducting the 1985-1987 Kalamazoo River creel surveys. He estimates that use of the central stretch has been on average about 20% of the total use in the stretch below Allegan Dam since the early 1990s and was about 10% before that (James Dexter, MDNR, personal communication, March 2001). The KRRRA study found that use in the stretch above Allegan Dam is currently about 37% to 39% of the use below the dam, suggesting the central stretch has been increasing in popularity over time. Table 2.2 shows the estimate of use for this central stretch. Here it is assumed that the central stretch had 10% of lower stretch use from 1985 to 1990, and thereafter a linear increase in use to the 2001 estimate from the KRRRA is assumed.

Lake Michigan

To estimate the number of Lake Michigan fishing days affected by the PCB contamination from the Kalamazoo River, two assumptions are made to generate different estimates of Lake Michigan losses. For the estimate considered to be most reliable, it is assumed that all fishing days near the Kalamazoo River (based on the Holland creel survey site data) are the only fishing days affected by the Kalamazoo River contamination, because other Great Lakes Areas of Concern are much farther from this creel survey area than is the Kalamazoo River. An average of 22,200¹¹ Lake Michigan fishing days occur in the Holland creel survey area each year (see Table 2.4).

The second method is a weaker approach. It is assumed that since 2.0% of the recent total PCB loadings into Lake Michigan is estimated to come from the Kalamazoo River (U.S. EPA, 2000), 2.0% of the existing Lake Michigan fishing days are affected by Kalamazoo PCB contamination. This approach requires the assumption that factors contributing to or underlying damages (e.g., use levels, population centers, FCAs) are uniform around Lake Michigan, which obviously is not true. Using the second approach, there would be an average of 13,500 affected Lake Michigan fishing days per year (which is based on 2% of the total Lake Michigan days) between 1985 and 2001. The second estimate of affected Lake Michigan days and total Lake Michigan days is reported in Table 2.4.

11. Average Holland fishing days are derived based on the years 1992-2001 only because Holland data for 1985-1991 do not exist.

Table 2.4. Estimate of fishing days for Lake Michigan area affected by the Kalamazoo River PCB contamination, April through October, 1985-2001

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Holland, MI creel area ^a	40,316	42,447	33,153	25,363	23,551	18,803	20,405	21,633	15,927	31,169	29,162	21,326	24,054	9,790	24,077	23,800	20,851
2.0% of Lake Michigan ^b	20,648	21,739	16,979	12,990	12,062	9,630	10,451	9,217	9,615	6,959	12,975	13,365	13,955	14,711	13,513	13,589	16,323
All of Lake Michigan	1,032,400	1,086,968	848,973	649,505	603,101	481,517	522,532	460,866	480,726	347,966	648,755	668,251	697,769	735,545	675,650	679,437	816,151

a. Holland, MI (site 156) is the closest Lake Michigan creel area to the Kalamazoo River. For 1985 through 1991, Holland data are unavailable. For these years Holland use is approximated by calculating the average ratio of Holland days to total Lake Michigan days for the years for which data are available, and then applying that ratio to total Lake Michigan days from 1985 through 1991.

b. Lake Michigan hours of angler effort were divided by 4.5 hours per trip. This average trip length was calculated from data from 1991-2000 for Lake Michigan sites on the southern east coast. Data from personal communication with G. Rakoczy, MDNR (March 2001).

Sources: 1985-1994 data from Rakoczy and Svoboda (1997); 1995 to 2000 data from personal communication with G. Rakoczy, MDNR (March 2001); 2001 data from personal communication with G. Rakoczy, MDNR (August 2002).

2.5 Estimates of Kalamazoo River Fishing Use in the Absence of FCAs (baseline)

Recreational angling use of the Kalamazoo River and Lake Michigan in the absence of FCAs might be higher than current use for several reasons: (1) existing anglers might substitute fishing days away from other sites to the Kalamazoo River (substituted days); (2) existing anglers might increase their number of fishing days per year, including Kalamazoo River days (foregone days); and (3) new participants who do not currently fish might use the resources for recreational angling. Only the first two categories of “reduced days” are estimated and substituted and foregone days are not distinguished from each other when reduced user days are estimated below.

In Atkin’s (1998) survey of Allegan and Kalamazoo County residents, he found that 77% of respondents were concerned about Kalamazoo River contamination and 24% were specifically concerned about contamination effects on fish and fishing. These individuals were not asked if they fish, but of these people concerned about fish and fishing (24%), 57% said the current level of contamination was keeping them from using the Kalamazoo River. This and other evidence discussed below suggests that contamination has reduced the number of recreational angling days on the Kalamazoo River.

To estimate how many more fishing days would be spent fishing the Kalamazoo River in the absence of PCB contamination, estimates from related studies and comparisons to other sites are used. In a 1999 study, Breffle et al. (1999) modeled the effects of changes in FCAs, launch fees, and catch rates in Green Bay on fishing use and values. Green Bay FCAs for consuming smallmouth bass and steelhead currently are “no more than one meal per month.” Other species have advisories that vary by fish size, and these advisories are shown in Appendix C (Table C.3). Compared to those for the Kalamazoo River and southern Lake Michigan, the Green Bay advisories are generally less stringent than those for the Kalamazoo River above Allegan Dam and more stringent than those for the Kalamazoo River below Allegan Dam and for southern Lake Michigan. Breffle et al. (1999, In press) found that eliminating FCAs from Green Bay would increase the number of fishing days from 2% to 15% among current Green Bay anglers (the study group).

Other studies have reported the effects on use of a change in angler catch rates, which is loosely relevant even though PCB removal may have no effect on stocks and catch rates of fish. Changes in catch rates are not the same as changes in FCAs, but nonetheless may be useful as indicators of the magnitude of changes in use as a response to a change in an important site characteristic. In Breffle et al. (1999), Green Bay anglers rated the importance (and value) of cleaning up contaminants such as PCBs dramatically higher than increasing angler catch rates. On this basis, the change in use estimated for catch rate increases might be interpreted as a conservative

estimate of the change in use that would result following a significant improvement in FCAs and PCB contamination.

Five of these catch studies along with the Green Bay PCB study are included in Table 2.5 to serve as indicators of the general magnitude of responses to changes in important recreational fishing site characteristics, even though changes in catch rates (and the magnitudes of those changes) are not directly related to FCAs. These studies estimated damages in both categories (substituted and forgone days), and the estimates are generally higher than Breffle et al.'s (1999, In press) estimates of the impact of eliminating FCAs.

Table 2.5. Changes in fishing use from change in conditions

Study	Area	Change modeled	Change
Breffle et al., 1999, In press	Green Bay, WI	Increase in days spent fishing Green Bay from substitution of days fishing from other sites when FCAs are removed	2% to 15%
Morey et al., 1993, 2001	Penobscot River, ME	Increase in total days spent fishing Penobscot River when catch is doubled	34% to 43%
Morey et al., 1995, 2002	Upper Clark Fork Basin, MT	Increase in total days spent fishing upper Clark Fork River when catch is increased 85%	66%
Shaw, 1985; Morey and Shaw, 1990	New York, with multiple, small fishing sites	Increase in total angler days when catch is doubled	10% to 40%

Another basis to approximate the change in user days under baseline conditions is to use the studies in Table 2.1 to obtain the percentage of all anglers (including those not aware of FCAs) who substitute away from contaminated sites (to other sites or other activities), which ranges from 11% to 45%, and the percentage of all anglers who fish less, which ranges from 5% to 37% (see Table 2.1). Atkin (1995) estimated that 29% of all anglers (including those not aware of FCAs) avoid fishing the contaminated sites (by substituting to other locations or fishing less overall). Using that figure and assuming all anglers spend the same number of days, and those who avoid contaminated locations do so for all of their days, an estimate of how much Kalamazoo River user days would increase under baseline conditions is 41%.¹² Again, this method provides only a rough approximation, because the percentage of anglers who avoid a site is a different variable than the percentage of days lost at a site. This discussion is used only as a guide in choosing an appropriate adjustment for lost days.

12. The percentage of anglers who avoid certain locations is 29%, and therefore the percentage who do not avoid certain locations is 71%. Under the strong assumption that all anglers spend the same number of days fishing, and those who avoid contamination do so for all their days, then use is decreased from 100% to 71%. 100 is 41% higher than 71: $100/71 = 1.41$.

Another approach uses results from the MSU recreation demand model, which is discussed in detail in Section 2.7 and Appendix D. Application of the MSU recreation demand model to the Kalamazoo River in Kalamazoo and Allegan counties demonstrates that recreational fishing would increase by almost 62% if PCBs had not been released. Further, the 62% increase is a lower-bound estimate because it includes other fishing sites besides the Kalamazoo River that are not improved in the simulation (although the Kalamazoo is the largest fishing site in these counties).¹³

Comparing the recreational fishing use on the Kalamazoo River to use on other Michigan rivers with lower or no FCAs provides another basis of estimating the number of days anglers would spend fishing the Kalamazoo River in the absence of PCB contamination. As discussed in Section 2.4, the St. Joseph and Kalamazoo rivers share some similarities; a major difference is that the St. Joseph River has less restrictive FCAs than the Kalamazoo River (see Appendix C, Table C.4).

While a St. Joseph River comparison is not the basis for selecting a factor to estimate the reduced number of fishing days, it does provide an additional means of evaluating the accuracy of the methods employed. As discussed earlier, in 1985-1987 the MDNR conducted creel surveys on both rivers using the same survey sampling methods. The 1985-1987 levels of use for the lower Kalamazoo River (below Allegan Dam) are compared to those for the St. Joseph River, which is particularly useful for the past. Because the data do not match exactly (months are missing for the Kalamazoo River), two different comparisons are made: one using all available data, and one using only data from the same months of the same years for which use data are available for the lower Kalamazoo River stretch. The former estimate probably provides a more accurate statistic for average use of the St. Joseph River, but the latter may be more useful for a direct comparison with the Kalamazoo River stretch.

The estimate for all months covered by the St. Joseph data is 13% higher per mile than the 1985-1987 levels of use on the Kalamazoo River. The per-mile estimate for only the selected St. Joseph data that conform to the months for which Kalamazoo data are available is 56% higher than 1985-1987 levels of Kalamazoo River use. A significant portion of the difference between the two rivers is expected to be attributable to PCB contamination.

Two estimates for the estimation of lost days are used. The low estimate is 15%, and the high estimate is 50%. The estimates of change in use (reduced days) are uncertain, which leads to a relatively large range in the predictions. Changes of 15% and 50% are in line with other estimates from the literature.

13. When other sites with no improvements are included, they dilute the percentage increase to the injured sites because no increase (or a relatively small increase if sites are complements) is expected for those other sites following cleanup.

Tables 2.6 and 2.7 show the estimates of the reductions in Kalamazoo River days in the central and lower stretches, above and below Allegan Dam, respectively, as a result of FCAs. Four estimates are presented for each stretch. The first two estimates apply the low estimate and the last two apply the high estimate of the percentage increases (under baseline) to the upper and lower bounds of the estimates of current Kalamazoo River fishing days, respectively. These are estimates of the reductions in user days, including both substituted and foregone days.

For the Kalamazoo River below Allegan Dam and for Lake Michigan, there are some years when not all species had FCAs for the general population. In these years, it is assumed that only potential fishing days for those species with advisories are lost. While there were no advisories for the general population, there were advisories for the special population of women and children. Most anglers are male adults and so the “unlimited consumption” advisory would apply to them. However, they may be concerned about the special advisory if they are fishing with family or intending to share meals with their families. If this concern affects the quality of their fishing days, then their damages have been underestimated. For example, in 2001, steelhead and salmon had no advisories for the general population, and they constitute about 80% of the fishing activity.¹⁴ As a result only the estimates of the percentages for the reduced days to the 20% of Kalamazoo River days are applied below Allegan Dam that were affected by advisories. This same approach was applied to each year in the past. For example, in 1992, 75% of Lake Michigan, 40% of lower Kalamazoo River, and 100% of central Kalamazoo River fishing days were spent targeting species with FCAs for the general population, and so the estimates of the percentage of reduced days are applied only to these affected days.

Table 2.8 shows the estimate of the reduction in Lake Michigan fishing days due to FCAs. Substitution may be lower because Great Lakes sites are unique. Lake Michigan fishing also requires a larger investment in equipment than river fishing (e.g., navigating and finding fish in the much larger waterbody requires a much larger boat at a minimum). Therefore Great Lakes anglers who have this equipment may have a lower response to FCAs in terms of the percentage reduction of days, because it is more difficult to substitute away from Lake Michigan. Likewise, anglers who currently do not have suitable equipment for Lake Michigan fishing might not substitute into Lake Michigan if FCAs were removed, at least in the short term. As such, for the estimate of reduced Lake Michigan fishing days due to PCB contamination, only the low estimate of reductions of 15% is used. For 1981-2001, the estimate for the average reduction in the number of Lake Michigan fishing days annually is between 1,600 and 3,100, depending on the total number of days assumed to be currently affected by Kalamazoo River PCB contamination.

14. The KRRRA study found that 79% of the anglers below Allegan Dam were fishing for trout, salmon, or “whatever is biting.” Dexter (see Section 2.2) estimates that 80% of anglers in this stretch are fishing for trout or salmon.

Table 2.6. Estimated reductions in central Kalamazoo River (Morrow Dam to Allegan Dam) fishing days due to Kalamazoo River FCAs (1981-2001)

Year	Estimate	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Days fished ^a	Low	4,860	4,860	0	3,888	4,860	4,860	4,860	4,652	4,443	4,235	4,533	4,831	5,130	5,428
	High	5,620	5,620	0	4,496	5,620	5,620	5,620	5,363	5,106	4,848	5,091	5,334	5,576	5,819
Reduction (low; 15%)	Low	729	729	0	583	729	729	729	698	666	635	680	725	769	814
	High	843	843	0	674	843	843	843	804	766	727	764	800	836	873
Reduction (high; 50%)	Low	2,430	2,430	0	1,944	2,430	2,430	2,430	2,326	2,222	2,117	2,267	2,416	2,565	2,714
	High	2,810	2,810	0	2,248	2,810	2,810	2,810	2,681	2,553	2,424	2,546	2,667	2,788	2,909

Table 2.6. Estimated reductions in central Kalamazoo River (Morrow Dam to Allegan Dam) fishing days due to Kalamazoo River FCAs (1981-2001) (cont.)

Year	Estimate	1995	1996	1997	1998	1999	2000	2001
Days fished ^a	Low	5,727	6,025	6,323	6,622	6,920	7,219	7,517
	High	6,061	6,304	6,547	6,789	7,032	7,274	7,517
Reduction (low; 15%)	Low	859	904	949	993	1,038	1,083	1,128
	High	909	946	982	1,018	1,055	1,091	1,128
Reduction (high; 50%)	Low	2,863	3,013	3,162	3,311	3,460	3,609	3,759
	High	3,031	3,152	3,273	3,395	3,516	3,637	3,759

a. Affected number of days fished are from estimates shown in Table 2.2, adjusted to include only those days when the target species had a general population FCA for each year. For example, in 1983 0% of central Kalamazoo fishing days were spent targeting a species that had a general population FCA, and in 1984 it was 80%.

Table 2.7. Estimated reductions in lower Kalamazoo River (downstream of Allegan Dam) fishing days due to Kalamazoo River FCAs (1981-2001)

Year	Estimate	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Days fished ^a	Low	41,310	41,310	38,880	38,880	41,310	7,290	12,150	11,629	11,108	10,587	10,065	15,271	14,437	13,603
	High	47,770	47,770	44,960	44,960	47,770	8,430	14,050	13,407	12,764	12,121	11,478	17,336	16,307	15,279
Reduction (low; 15%)	Low	6,197	6,197	5,832	5,832	6,197	1,094	1,823	1,744	1,666	1,588	1,510	2,291	2,166	2,040
	High	7,166	7,166	6,744	6,744	7,166	1,265	2,108	2,011	1,915	1,818	1,722	2,600	2,446	2,292
Reduction (high; 50%)	Low	20,655	20,655	19,440	19,440	20,655	3,645	6,075	5,814	5,554	5,293	5,033	7,635	7,219	6,802
	High	23,885	23,885	22,480	22,480	23,885	4,215	7,025	6,704	6,382	6,061	5,739	8,668	8,154	7,639

Table 2.7. Estimated reductions in lower Kalamazoo River (downstream of Allegan Dam) fishing days due to Kalamazoo River FCAs (1981-2001) (cont.)

Year	Estimate	1995	1996	1997	1998	1999	2000	2001
Days fished ^a	Low	6,385	5,968	5,551	5,134	4,717	4,300	3,883
	High	7,125	6,611	6,096	5,582	5,067	4,553	4,039
Reduction (low; 15%)	Low	958	895	833	770	708	645	582
	High	1,069	992	914	837	760	683	606
Reduction (high; 50%)	Low	3,192	2,984	2,775	2,567	2,359	2,150	1,942
	High	3,562	3,305	3,048	2,791	2,534	2,276	2,019

a. Affected number of days fished are from estimates shown in Table 2.2, adjusted to include only those days when the target species had a general population FCA for each year. For example, in 2001 20% of lower Kalamazoo fishing days were spent targeting a species that had a general population FCA, whereas in 1992 it was 40%.

Table 2.8. Estimate of Lake Michigan lost fishing days due to Kalamazoo River PCB contamination (1981-2001)

Days affected by Kalamazoo		1981 ^a	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Lake Michigan days ^b	2.0% of all LM	17,551	20,648	20,648	20,648	20,648	16,305	12,735	9,743	9,047	7,223	7,838	6,913	7,211	5,219
	LM at Holland	34,268	40,316	40,316	40,316	40,316	31,835	24,865	19,023	17,664	14,103	15,304	16,225	11,945	23,377
Lost days (15%)	2.0% of LM	2,633	3,097	3,097	3,097	3,097	2,446	1,910	1,461	1,357	1,083	1,176	1,037	1,082	783
	LM at Holland	5,140	6,047	6,047	6,047	6,047	4,775	3,730	2,853	2,650	2,115	2,296	2,434	1,792	3,507

Table 2.8. Estimate of Lake Michigan lost fishing days due to Kalamazoo River PCB contamination (1981-2001) (cont.)

Days affected by Kalamazoo		1995	1996	1997	1998	1999	2000	2001
Lake Michigan days ^b	2.0% of all LM	9,731	4,010	4,187	4,413	4,054	4,077	4,897
	LM at Holland	21,872	6,398	7,216	2,937	7,223	7,140	6,255
Lost days (15%)	2.0% of LM	1,460	601	628	662	608	611	735
	LM at Holland	3,281	960	1,082	441	1,083	1,071	938

a. Holland data are unavailable from 1981 through 1991. For these years Holland use was approximated by calculating the average ratio of Holland days to total Lake Michigan days for the years for which data are available (1982-2001), and then applying that ratio to total Lake Michigan days from 1981 through 1991. Lake Michigan days from 1981-1984 are assumed to be equal to the 1985 values.

b. Affected number of days fished are from estimates shown in Table 2.4, adjusted to include only those days when the target species had a general-population FCA for each year. For example, in 2001, 30% of Lake Michigan days were spent targeting a species with a general population FCA, whereas in 1988 it was 75%.

2.6 Estimates of Economic Values for Reduced Quantity and Quality of Fishing

In 1996 anglers spent over \$1.5 billion on recreational fishing in Michigan (U.S. DOI, 1998). Anglers clearly value their fishing experiences, but figures on total expenditures do not tell us how they value fishing days at specific sites above and beyond their costs. There is a large body of nonmarket economic valuation literature that estimates recreational fishing demand and determines the monetary values anglers place on the different characteristics of fishing. Peer-reviewed literature that is relevant to the reduced value of a fishing day at contaminated sites and to the valuation of lost use at contaminated sites is reviewed below.

Values for reduction in quality of fishing days spent at contaminated sites

This section presents the estimates of consumer surplus per fishing trip or day for reductions in contamination. In this context consumer surplus is defined as anglers' willingness to pay for reductions in contamination (net of fishing costs).

As shown in Table 2.9, the values anglers place on cleaner waters and fish are substantial,¹⁵ but vary across site, type of contamination, levels of contamination, shares of trips affected by FCAs, substitute sites available, and other factors. Several studies value reductions in contamination for Lake Michigan, but none are specific to Michigan rivers. Adjustments have to be made to estimate a range of values to be used in the benefits transfer for this assessment area.

Breffe et al. (1999) estimated the lost value for nine levels of FCAs in Green Bay (see Table 2.9 for description). The value per Green Bay fishing day for the elimination of different levels of FCAs is shown in Table 2.10. Five of these levels are relevant to current FCAs for the Kalamazoo River and southern Lake Michigan. In the central Kalamazoo River, above Allegan Dam, the current FCA on smallmouth bass most closely resembles the Breffe et al. Level 9, and the current FCA on walleye and northern pike most closely resembles Level 3. In the lower Kalamazoo River below Allegan Dam, the current FCA on smallmouth bass most closely resembles Level 3; the current FCA on walleye most closely resembles Level 2; and the current FCAs on steelhead and salmon most closely resemble Level 1 or 2.¹⁶ In southern Lake Michigan, the current FCA on trout most closely resembles Level 5, and the current FCA on steelhead and salmon most closely resembles Level 1. Level 1 (unlimited consumption of all fish) is used as the baseline for all stretches.

15. All values shown are in dollars adjusted to 2001 (2001\$).

16. There are FCAs on steelhead and salmon. However, for the general population it is "unlimited consumption" and for the special population it is "once per week or month" depending on the size of fish.

Table 2.9. Selected valuation studies for the reduction of toxins at fishing sites

Authors	Study location	Sample information	Model	Resource change	Value estimates (2001\$) ^a
Breffle et al., 1999	Green Bay and Fox River, 1999	647 Green Bay anglers who purchased licenses in 8 WI counties near Green Bay	Combined revealed-stated preference random utility model	Reduction in FCA levels ^b Level 9 to Level 1 Level 5 to Level 1 Level 3 to Level 1 Level 2 to Level 1	\$24 per fishing day \$12 per fishing day \$5 per fishing day \$2 per fishing day
Chen and Cosslett, 1998	Michigan Great Lakes sites	338 one-day salmon fishing trips	Simulated maximum likelihood random parameter probit model	Remove Area of Concern designation at all Michigan Great Lakes sites (total of 14)	\$4 to \$18 per Great Lakes fishing trip
Hauber and Parsons, 1998	Maine lakes and rivers	143 Maine anglers 2,425 freshwater fishing day trips	Nested logit random utility model (RUM)	Clean up all Maine rivers having FCAs	\$2 per trip
Herriges et al., 1999	Wisconsin waters of Great Lakes	240 Great Lakes trout and salmon anglers, and 247 non-Great Lakes anglers (data from Lyke, 1993)	Kuhn-Tucker models	20% reduction in contaminant levels in fish	\$11 to \$14 per Great Lakes fishing day \$81 to \$100 per angler per season
Jakus et al., 1997	Reservoirs in middle and eastern Tennessee	368 Tennessee reservoir anglers	Repeated discrete choice RUM (for annual), multinomial logit site-choice model (for per trip)	Remove FCAs from 6 of 14 eastern Tennessee reservoirs Remove FCAs from 2 of 14 middle Tennessee reservoirs	\$8 per trip to contaminated site \$130 per angler per season \$16 per trip to contaminated site \$190 per angler per season

Table 2.9. Selected valuation studies for the reduction of toxins at fishing sites (cont.)

Authors	Study location	Sample information	Model	Resource change	Value estimates (2001 dollars)^a
Jakus et al., 1998	Reservoirs in Tennessee	222 Tennessee reservoir anglers	Multinomial logit site choice model -Valuation considers whether angler knows about advisories	Remove FCAs from 6 of 14 total Tennessee reservoirs	\$1 per trip (assumes all anglers know about FCA) \$4 per trip (across all anglers, but assuming those who do not know have zero loss)
Lyke, 1993	Wisconsin Great Lakes	274 Great Lakes trout and salmon anglers, and 239 inland anglers	Contingent valuation -Linear logit (LL) -Constant elasticity of substitution (CES)	Eliminate all contaminants that threaten human health in Wisconsin Great Lakes	\$4 (LL) to \$15 (CES) per Great Lakes fishing day \$51 (LL) to \$179 (CES) per angler per year
Parsons et al., 1999	Reservoirs in middle Tennessee	143 middle Tennessee reservoir anglers	Various RUMs	Remove FCAs from 2 of 14 middle Tennessee reservoirs	\$15 to \$16 per trip to contaminated site

a. Estimates of values are for fishing days at the contaminated sites. Where the models estimate the value for all sites (contaminated and uncontaminated), the value was divided by the percentage of the days that are at sites that are contaminated. This calculation is discussed in the text associated with this table.

b. Level 9 = “do not eat” for trout/salmon, walleye, and smallmouth bass; Level 5 = “do not eat” for walleye and “one meal per month” for trout/salmon and smallmouth bass; Level 3 = “one meal per month” for trout/salmon and walleye and “one meal per week” for smallmouth bass; Level 2 = “one meal per week” for trout/salmon and walleye and “unlimited consumption” of smallmouth bass; Level 1 = “unlimited consumption” for all species.

Table 2.10. Value of reduction in quality of existing fishing days from Breffle et al. (1999)

FCA level	FCA level description	Value per Green Bay fishing day to reduce FCAs from listed level to Level 1 (baseline) (2001\$)
9	<ul style="list-style-type: none"> • Yellow perch – Eat no more than 1 meal a month • Trout/salmon – Do not eat • Walleye – Do not eat • Smallmouth bass – Do not eat 	\$23.52
5	<ul style="list-style-type: none"> • Yellow perch – Unlimited consumption • Trout/salmon – Eat no more than 1 meal a month • Walleye – Do not eat • Smallmouth bass – Eat no more than 1 meal a month 	\$12.16
3	<ul style="list-style-type: none"> • Yellow perch – Unlimited consumption • Trout/salmon – Eat no more than 1 meal a month • Walleye – Eat no more than 1 meal a month • Smallmouth bass – Eat no more than 1 meal a week 	\$5.27
2	<ul style="list-style-type: none"> • Yellow perch – Unlimited consumption • Trout/salmon – Eat no more than 1 meal a week • Walleye – Eat no more than 1 meal a week • Smallmouth bass – Unlimited consumption 	\$1.96
1	<ul style="list-style-type: none"> • Yellow perch – Unlimited consumption • Trout/salmon – Unlimited consumption • Walleye – Unlimited consumption • Smallmouth bass – Unlimited consumption 	\$0.00

Chen and Cosslett (1998) used data collected on 338 single-day fishing trips targeting trout or salmon. The choice set includes 41 possible sites in the Michigan waters of the Great Lakes. They estimated three models of fishing demand: a varying parameter multinomial probit model, an independent multinomial logit model, and an independent multinomial probit model. They valued the cleanup of toxic contamination at 14 sites in the Great Lakes waters of Michigan sufficient to remove the designation of Area of Concern by the International Joint Commission.

The values for this cleanup range from \$1.29 to \$6.08 per trip. These values are applicable to Lake Michigan, but less so to the central Kalamazoo River, which has only warm water species (the lower Kalamazoo River is not relevant either because the salmonids coming up the river have no FCAs for the general population). Values apply to all trips taken in the 41-site region, including those without contamination. The 14 affected sites accounted for 34% of the total sites,

implying a very rough estimate of the value per trip to an affected site of about \$4 to \$18 [(\$1.29 to \$6.08)/0.34].¹⁷

Three studies listed in Table 2.9 (Jakus et al., 1997, 1998; Parsons et al., 1999) estimated the value of reducing toxic contamination to the degree that FCAs could be removed from contaminated reservoirs in Tennessee. These studies concentrated on different geographic regions of Tennessee and include both toxic and nontoxic sites. The toxic sites are those with an advisory; they are distinguished by an indicator variable that equals one if an advisory is present and zero if it is not present at the site. The advisories may be for different levels of restrictions, but these levels are not modeled. The models developed are all random utility models, and the population is limited to anglers who use the sites. It should be emphasized that the per-trip values from all of these studies are for trips to all sites modeled, including nontoxic sites. These values do not apply only to the trips taken to the toxic sites.

In Jakus et al. (1997), the value estimated for removing FCAs from 2 toxic sites within a 14-site region is about \$2.20 per trip. Because two sites constitute 14% of all 14 sites in the study, a rough first approximation of the per-trip value of cleanup for only the affected sites is \$16 (\$2.20/0.14).

In Jakus et al. (1998), the values for removing FCAs from 6 toxic sites within a 14-site region are \$1.64 from a multinomial logit site-choice model with the assumption that anglers who did not know about FCAs had zero loss, and \$8.02 in the same model with the assumption that all anglers knew about FCAs. The 6-site subset represents 43% of the total number of sites, so a rough first approximation of the losses per trip to the contaminated sites ranges from about \$4 to \$19 [(\$1.64 to \$8.02)/0.43]. The system of reservoirs may be more comparable with the Kalamazoo River than Lake Michigan is because the reservoirs offer smaller waters with similar nontoxic, warm water substitutes.

Lyke (1993) collected data on fishing in Wisconsin in 1989. She used part of the data (surveys returned by 274 anglers who fished the Wisconsin Great Lakes) to develop two contingent valuation models. She estimated that eliminating all contaminants that threaten human health from the Wisconsin Great Lakes would be worth \$51.01 to \$179.36 per angler per year. Dividing by her sample average of 12.16 Great Lakes fishing days per angler, the values per Great Lakes fishing day range from \$4 to \$15.

17. This value range (\$1.29 to \$6.08) is a per-trip value for cleanup that applies to all sites, including ones that are not contaminated. If the value is instead to be assigned only to trips to contaminated sites, which account for 34% of all sites, the values are weighted upward by a factor of 1/0.34.

Herriges et al. (1999) used Lyke's (1993) data from Wisconsin anglers to develop and estimate two utility-theoretic Kuhn-Tucker models of recreation demand.¹⁸ The models value a 20% reduction in toxins at four aggregate Wisconsin Great Lakes sites (Lake Superior, North Lake Michigan, South Lake Michigan, and Green Bay). The models indicate toxins in the Great Lakes significantly reduce the well-being of Wisconsin anglers. Site-specific values are not presented, but the range of values for a 20% reduction in toxins at all four sites is \$80.79 to \$99.74 per angler per year. For comparison to the other studies, the annual values in Herriges et al. (1999) are divided by the average number of Great Lakes fishing days per angler estimated in that study (7.31) to obtain values per Great Lakes fishing day of \$11 to \$14.

The Breffle et al. (1999) estimates fall within the range of the other studies discussed above and are used in this benefits transfer because they are specific to the type of change that needs to be valued. They are the best estimates for Lake Michigan damages, but an adjustment will be made to the estimates for the Kalamazoo River because river fisheries generally have lower per day fishing values (and therefore lower absolute values for changes in characteristics) than Great Lakes fisheries.

The middle of the range of per day values for a Great Lakes fishing day falls between \$40 and \$60, and the middle of the range of per day values for rivers and warm water fisheries falls between \$30 and \$40 (see Table 2.11, discussed in the next section). This would suggest river values are between two-thirds (40/60) and three-fourths (30/40) those of the Great Lakes. To be conservative, the Breffle et al. (1999) estimates are adjusted by two-thirds before applying them to Kalamazoo River fishing days. Therefore, for the Kalamazoo River, the per fishing day value is \$15.68 going from FCA Level 9 to Level 1, \$8.10 from Level 5 to Level 1, \$3.51 from FCA Level 3 to Level 1, and \$1.31 from FCA Level 2 to Level 1 (see Table 2.10 for an explanation of levels). Adjusting for the mix of species and their portion of user days (based on the MDNR and KRRRA data discussed earlier), the current value of the loss to existing fishing days is estimated to be \$13.25 for the central Kalamazoo River (between Morrow Lake Dam and Allegan Dam),¹⁹ \$0.59 for the lower Kalamazoo River (below Allegan Dam),²⁰ and \$2.43 for Lake Michigan.²¹ As seen in the calculations in footnotes 20 and 21, the lower Kalamazoo River and Lake Michigan fisheries are dominated by cold water species, and these species have no advisories for the general population. As mentioned earlier, there is an advisory for cold water species for the

18. Other types of models are also estimated, but those models are not utility theoretic and often give implausible results that are not consistent with expectations. However, all estimated models indicate that toxins reduce the amount and quality of recreational fishing services.

19. $\$15.68 \text{ (Level 9)} \times 80\% \text{ (smallmouth bass)} + \$3.51 \text{ (Level 3)} \times 20\% \text{ (walleye and northern pike)}$.

20. $\$0 \text{ (Level 1)} \times 80\% \text{ (steelhead and salmon)} + \$3.51 \text{ (Level 3)} \times 15\% \text{ (walleye)} + \$1.31 \text{ (Level 2)} \times 5\% \text{ (smallmouth bass)}$.

21. $\$0 \text{ (Level 1)} \times 70\% \text{ (steelhead and salmon)} + \$8.10 \text{ (Level 5)} \times 30\% \text{ (trout)}$.

Table 2.11. Per-day consumer surplus values for river and Great Lakes recreational fishing (reported in 2001\$)

Study	Location	Valuation method	Estimated value
Boyle et al., 1999	Great Lakes bass and salmon fisheries	Meta-analysis (TCM)	\$70-\$85 per day ^a
	River bass and salmon fisheries	Meta-analysis (TCM)	\$32-\$46 per day ^a
Charbonneau and Hay, 1984	Bass fisheries nationwide	CVM	\$62 per day
	Landlocked salmon fisheries nationwide	CVM	\$69 per day
Connelly et al., 1990	New York Great Lakes	CVM	\$22 per day
Duffield et al., 1992	Big Hole and Bitterroot rivers, Montana recreational trip by float angler	Dichotomous choice CVM	\$72-\$130 per day
Herriges et al., 1999	Southern Lake Michigan fishing	Kuhn-Tucker	\$99-\$108 per day
Kealy and Bishop, 1986	Wisconsin portion of Lake Michigan	TCM	\$53 per day
Layman et al., 1996	Gulkana River, Alaska salmon fishing	TCM	\$34-\$45 per day
Loomis, 1998	Northeast fishing (includes Michigan)	Meta-analysis	\$26 per day ^b
Lyke, 1993	Wisconsin Lake Michigan fishing	Multinomial logit TCM	\$25 per trip
Menz and Wilton, 1983	New York portion of Lake Ontario	Zonal TCM	\$48-\$137 per day
	New York portion of St. Lawrence River	Zonal TCM	\$81-\$155 per day
Milliman et al., 1992	Green Bay yellow perch fishery	Dichotomous choice CVM	\$42 per trip
Walsh et al., 1990	Warm water fishing nationwide	Meta-analysis	\$40 per day
	Cold water fishing nationwide	Meta-analysis	\$52 per day

a. Regression parameters used to predict values were estimated using 286 consumer surplus data points from 15 studies. The estimated values reported here are based on the assumption the travel cost method was applied using data from a mail survey.

b. Combines 40 studies from the Northeast region of the United States.

special population. These calculations are conservative because they do not account for female anglers of childbearing years, children, or those anglers in the general population who may fish or share fish with their families and therefore be concerned with the advisory for special populations.

Values for reductions in fishing days

Anglers may respond to contamination by reducing the number of days they spend at a site, as discussed in Section 2.5. When they choose not to go to a site in response to an injury, they are worse off than if there were no injury. Table 2.11 summarizes studies that value a day of fishing at rivers and Great Lakes sites based on consumer surplus measures (i.e., willingness to pay to spend a day fishing, over and above costs). Most of these studies consider substitution and losses when a site is closed, but in this case, the Kalamazoo River remains open to fishing. However, for those anglers who choose to substitute their fishing activity to other sites, or to forego some days they would have fished the Kalamazoo River, it can be inferred that contamination may be sufficient for them not to consider the Kalamazoo River as an option some or all of the time.

Anglers may choose to go to a substitute site instead of foregoing their day of fishing entirely. In this case they may mitigate some of the loss they experience from not fishing the injured site. Because a model to estimate participation and substitution patterns in the Kalamazoo River fishery or how these behavioral changes are linked to changes in value does not exist, it is not possible to differentiate the changes in use or values of “foregone” versus “substituted” days. The comparison studies in Table 2.11 measured average values across substituted and foregone fishing days; because these studies were conducted with existing anglers, they tend to overemphasize substitution (missing the days foregone by those anglers who have dropped out). Therefore a range of values is considered that is used to estimate the value of a reduction in Kalamazoo River fishing days.

Per day values (2001\$)

This section summarizes the literature in Table 2.11. The Kalamazoo River supports both cold- and warm water species (although warm water species have more restrictive advisories) and so studies of the value of a day of fishing for warm and cold water species are discussed below.

Milliman et al. (1992) developed a model of the commercial and recreational yellow perch fisheries in Green Bay. They estimated the value of a perch fishing day to recreationists to be \$42 per angler. Using a multinomial logit travel cost model (TCM), Lyke (1993) found the value of a Wisconsin Southern Lake Michigan fishing day to be \$25. Herriges et al. (1999) used a subset of the same data to estimate Kuhn-Tucker models of site selection and participation. With the same policy scenario as Lyke, the loss of southern Lake Michigan fishing, they estimated the value of a southern Lake Michigan fishing day to be \$99 to \$108.

Menz and Wilton (1983) estimated three zonal TCMs for the New York portions of the St. Lawrence River and Lake Ontario. Their estimates vary by the method used and by the county in which the fishing took place. For the St. Lawrence River, their per day estimate of the value of fishing varies between \$81 and \$155, and for Lake Ontario the value varies between \$48 and \$137. In this case the value of fishing on the river is higher than on the Great Lakes, because the river is a very large estuarine river. Fishing in this river is likely more comparable to the Great Lakes or ocean bays and estuaries than to most inland waters.

Connelly et al. (1990) estimated the average value of a day of fishing for all inland New York sites (inland river, lakes, estuaries, and Great Lakes) using the contingent valuation method (CVM). They found on average New York anglers were willing to pay \$22 per fishing day.

Charbonneau and Hay (1984) used the data from the 1975 U.S. FWS National Survey of Hunting, Fishing and Wildlife Associated Recreation to estimate the value of fishing and hunting for various species. Estimates were derived using CVM. The national average values for a day of bass and land-locked salmon fishing were \$62 and \$69 per site, respectively.

While several studies of Great Lakes angling values are available, fewer exist for comparable river angling. Duffield et al. (1992) studied the net economic benefits of in-stream flows for the Big Hole and Bitterroot rivers in Montana. Using a dichotomous choice CVM, they calculated the value of a recreational trip for a resident float angler to be \$72 for the Bitterroot River and \$130 for the Big Hole River. These values are useful because they are for river fishing, but are likely high estimates for the Kalamazoo River, since this area of Montana is renowned for trout and salmon fly fishing and attracts anglers nationwide.

Layman et al. (1996) used a TCM to value fishing on the Gulkana River, a cold water fishing stream in Alaska. The value of a day of fishing was found to be \$34-\$45. This value is closer to the range found in several meta-analyses of fishing in the Northeast and nationwide. This stream is a popular destination for whitewater rafting, multiday canoe trips, and trout and salmon fishing.

Boyle et al. (1999) designed a meta-analysis of sportfishing values from 70 studies to generate 1,002 per-day and per-trip welfare estimate observations. Per-day welfare estimates were computed by increasing the implicit price of the fishing day at each site to the point that the site was “eliminated” from all respondents’ choice sets. A day of smallmouth bass fishing was estimated to be worth \$32 on a river and \$70 on a Great Lake, while a day of salmon fishing was estimated to be worth \$46 on a river and \$85 on a Great Lake.

Walsh et al. (1990) also did a meta-analysis of sportfishing values. They combined travel cost and contingent valuation demand studies from 1968 to 1988 to assess the value of a day of fishing. Using 39 studies they found a mean value of \$52 for a day of cold water fishing and

using 23 studies they found a mean value of \$40 for a day of warm water fishing. A third meta-analysis by Loomis (1998) combined 40 studies from the Northeast region of the United States; he found a value of \$26 per fishing day.

Across the above studies, values for a day of warm water river fishing range from \$26 to \$65, with most studies averaging \$30-\$40. Cold-water river and Great Lakes fishing days have higher values, ranging from \$34 to \$129, with most between \$40 and \$60.

Incremental travel costs (2001\$)

As an alternative, the loss from substituting fishing to other sites can be approximated as the value of the added travel cost to fish at substitute sites instead of the Kalamazoo River. If we assume anglers are substituting from the Kalamazoo River to the St. Joseph, the closest comparable substitute, the difference in round trip travel distance is approximately 30 miles. An estimate of their vehicle operating costs is \$10.35 per day, although this would vary by the angler's point of origin. This estimate is calculated using the federal vehicle mileage reimbursement to approximate cost of travel (34.5 cents/mile) multiplied by the extra mileage (30 miles). Including the value of their time (a half-hour of travel at a typical assumption of one-third the average hourly wage rate for Allegan and Kalamazoo counties; the average hourly wage rate is \$13.44) increases the total loss to \$12.71 per day.

Because an estimate of how many of the lost user days are substituted versus foregone is not available, a value of \$20 is applied to both types of reductions in user days for the central and lower Kalamazoo River. This value lies between the range of \$30 and \$40 in the literature (Table 2.9) and an incremental travel cost estimate of \$10.35 or \$12.71. For Lake Michigan higher values for lost days are applied. Values for a day of fishing on Lake Michigan and other Great Lakes fishing range from \$40 to \$60 with only a few outliers (see Table 2.11). As such we use a per-day value of \$50 for the damages to anglers who reduce their Lake Michigan user days.

2.7 Results: 2001 Damage Estimates

In this section, damages for a sample year, 2001, are estimated. Damages in other years are estimated in a similar manner, as discussed in Section 2.8. Two approaches are used to compute annual damages for 2001. The first benefits transfer method is based on use estimates in Sections 2.4 and 2.5 and per-day value estimates in Section 2.6. The second is based on the MSU recreation demand model simulation of damages.

2001 damages from reduction in quality of existing fishing days

In the 2001 KRRRA study it was estimated there were 19,416 to 20,193 fishing days on the lower Kalamazoo River and 7,517 on the central Kalamazoo River. As discussed above, making adjustments (for species mix and for river versus Great Lakes fishing) to the Breffle et al. (1999) estimates, the damages for the reduction in quality for a day of fishing are estimated to be \$13.25 for the central Kalamazoo River, \$0.59 for the lower Kalamazoo River, and \$2.43 for Lake Michigan. Annual damages for the reduction in quality of Kalamazoo River and Lake Michigan fishing for 2001 are estimated to be from \$150,800 to \$162,200 (see Table 2.12).

Table 2.12. Annual damages for reduction in quality of existing fishing days and reduction in fishing days on the Kalamazoo River and Lake Michigan (2001\$)

	Number of days	Per day value of damages	Damages (2001\$) ^a
Quality losses			
Central Kalamazoo River	7,517	\$13.25 ^b	\$99,600
Lower Kalamazoo River	19,416 to 20,193	\$0.59 ^b	\$11,500 to \$12,000
Lake Michigan	16,323 to 20,851	\$2.43 ^b	\$39,700 to \$50,700
Total quality losses	43,256 to 48,561		\$150,800 to \$162,200
Reduced fishing days losses			
Central Kalamazoo River	1,128 to 3,759	\$20	\$22,600 to \$75,200
Lower Kalamazoo River	582 to 2,019	\$20	\$11,600 to \$40,400
Lake Michigan	735 to 938	\$50	\$36,800 to \$46,900
Total reduced fishing losses	2,445 to 6,716		\$71,000 to \$162,500
Quality losses and reduced fishing losses			
All areas	45,701 to 55,277		\$221,700 to \$324,700

a. Rounded to nearest 100.
b. Figures rounded for presentation.

2001 damages from reduced fishing days

It is estimated that in 2001 from 1,710 to 5,778 fishing days were not taken to the Kalamazoo River and 735 to 938 fishing days were not taken to Lake Michigan because of Kalamazoo River contamination (see Tables 2.6, 2.7, and 2.8). In Section 2.6 the value of a Kalamazoo River fishing day was estimated to be \$20 and the value of a Lake Michigan fishing day was estimated to be \$50. Therefore the damages from reduced fishing days to the Kalamazoo River and Lake Michigan in 2001 range from \$71,000 to \$162,500 (see Table 2.12). Total damages from both reduction in quality of existing fishing days and reduced fishing days in 2001 (excluding winter fishing) were between \$221,700 and \$324,700.

Annual estimate of recreational fishing damages based on MSU model

Another estimate of Kalamazoo River recreational fishing damages can be derived from a simulation using the MSU statewide recreation demand model. This model estimates changes in seasonal use patterns and values from changes in site characteristics such as river quality. The simulation was conducted by Dr. Frank Lupi at MSU, who also contributed to the design of the model. The MSU model is described in Appendix D, along with a detailed description of the analysis and results. Only a summary of the conclusions is provided here.

This simulation is based on an improvement in quality from “secondary quality” to “top quality” for over 74 miles of warm water stream, the length of the PCB-injured stretch of the Kalamazoo River, in Allegan and Kalamazoo counties. The secondary quality designation can be the result of pollution, and absent the PCB contamination, the Kalamazoo River might be designated top quality. The MSU model does not include a quality variable for anadromous stretches of rivers, so the model cannot be used to compute damages for the anadromous fishery. Similarly, because the quality of inland lakes is not included in the MSU model, the length of Lake Allegan is included in the estimate of affected Kalamazoo River miles.

Simulated recreational Kalamazoo River fishing damages to anglers living in Michigan for the April to October season are \$442,000 (2001\$). As a result, the MSU results support the damage estimates developed based on the benefits transfer approach. The simulated damages exceed the estimated range of \$221,700-\$324,700 based on benefits transfer, suggesting the latter approach gives conservative estimates. Subsequent computations are based on the benefits transfer method.

2.8 Results: Aggregating Damages over Time

In this section damages are aggregated over time. Past and present damages are estimated in the same manner as for 2001 based on the actual FCAs by year, detailed estimates of use by year, and an assumption of constant values through time; i.e., if a day of fishing is worth \$20 (2001\$) in 1999, it is also worth \$20 (2001\$) in 1985 and all other years. This is a simplifying assumption to make the analysis tractable for an estimate based on existing data. Future damages are computed under alternative assumptions of restoration time paths. A 3% real discount rate is used to escalate past damages and discount future damages to 2003.²² A 3% discount rate is

22. A discount rate accounts for the fact that if a person was paid for the damages that occurred in a past year in that year they could have invested that money and received a return. If they are paid in the current year for a past year's damages, they must also be compensated for that lost interest. Conversely, if they are paid for future damages in the current year, the value for that future year must be discounted to reflect that the payee can invest that payment now and receive a return in the future.

consistent with the average real three-month Treasury bill rates from 1985 through 1999 (Bureau of Economic Analysis, 1998; Federal Reserve, 1999) and is consistent with DOI implementation guidance (U.S. DOI, 1995) for NRDA's under 43 CFR §11.84(e).

The aggregate damages are reported in real 2001\$ for all years. Therefore, the estimates account for changes in the purchasing power of money, and reflect the value of 2001 dollars. [The consumer price index (CPI) was used to adjust for inflation.]

Past damages

To estimate damages beginning in 1981 for the reduction in quality of fishing days spent fishing in the assessment area in the past, the same method discussed in Section 2.6 is used to adjust the per-day damage estimates from Breffle et al. (1999) to State of Michigan FCA levels for the Kalamazoo River, specific to each of the past years (see Appendix C for FCA levels through time). These adjusted values are then applied to the estimates of fishing days in past years as shown in Table 2.2. It is assumed that the value of a fishing day has remained constant through these years, and for reductions in past use the values discussed in Section 2.6 are applied to the estimates of reductions in fishing days to the Kalamazoo River and Lake Michigan. Values by category are presented in Table 2.13. Past damages range from \$9.4 to \$19.8 million.

Table 2.13. Present value (in 2003) of past recreational fishing damages through 2002 (expressed as 2001\$)

	Quality losses (millions)	Reduced fishing days losses (millions)	Total damages (millions) ^a
Kalamazoo River			
Past damages (1981-2002)	\$2.9 to \$3.2	\$2.2 to \$8.2	\$5.1 to \$11.4
Lake Michigan			
Past damages (1981-2002)	\$1.7 to \$3.2	\$2.6 to \$5.2	\$4.4 to \$8.4
Kalamazoo River and Lake Michigan			
Past damages (1981-2002)	\$4.6 to \$6.4	\$4.8 to \$13.4	\$9.4 to \$19.8

a. Figures may not sum due to rounding.

Additionally, in 1997 EPA issued a supplementary advisory for the Michigan waters of Lake Michigan. This advisory was more stringent than the advisory issued by the State of Michigan. The estimates herein are based on the Michigan FCA levels. However, for comparison, in 1997 damages to the Lake Michigan fishery calculated under the Michigan FCAs were between \$116,000 and \$200,000, but using the EPA FCA, they would have been between \$260,000 and \$448,000. Damages for the Kalamazoo River under the State of Michigan FCA were between \$172,000 and \$287,000, but using the EPA FCA they would have been between \$457,000 and \$803,000.

Future damages

Future damages depend on the timeline for recovery. Because the recovery period is not known, for sensitivity analysis three potential remediation scenarios are assumed, as in the Green Bay NRDA (Breffle et al., 1999): no action (100 years), intermediate cleanup (40 years), and intensive cleanup (20 years). Under no action it is assumed the FCAs will remain in place for 100 years, reduced by one level after 50 years and eliminated after 100 years.²³ For the remediation scenarios it is assumed cleanup takes 10 years and then the FCAs are reduced by one level halfway through the remainder of the period.²⁴ Table 2.14 shows the present value (in 2003) of future damages to the Kalamazoo River and Lake Michigan under the potential cleanup scenarios. Future values for the Kalamazoo River and Lake Michigan range from \$7.6 to \$10.9 million for no action, \$5.1 to \$7.4 million for intermediate cleanup, and \$3.6 to \$5.1 million for intensive cleanup.

Table 2.14. Present value (in 2003) of future recreational fishing damages starting in 2003 (expressed as 2001\$)

	Quality losses (millions)	Reduced fishing days losses (millions)	Total damages (millions)
Kalamazoo River			
Future damages with no cleanup recovery (2003-2102)	\$3.4	\$1.0 to \$3.2	\$4.4 to \$6.7
Future damages with intermediate cleanup (2003-2042)	\$2.3	\$0.7 to \$2.2	\$2.9 to \$4.5
Future damages with intensive cleanup (2003-2022)	\$1.6	\$0.4 to \$1.5	\$2.0 to \$3.1
Lake Michigan			
Future damages with no cleanup (2003-2102)	\$2.3 to \$2.9	\$1.0 to \$1.3	\$3.3 to \$4.2
Future damages with intermediate cleanup (2003-2042)	\$1.5 to \$1.9	\$0.7 to \$1.0	\$2.2 to \$2.9
Future damages with intensive cleanup (2003-2022)	\$1.1 to \$1.4	\$0.5 to \$0.6	\$1.5 to \$2.0

23. Reducing FCAs by one level means FCAs of “do not eat” go down one level to “no more than one meal per month,” FCAs of “no more than one meal per month” go down to “no more than one meal per week,” and FCAs of “no more than one meal per week” go down to “unlimited consumption.”

24. Here it is assumed that cleaning up the Kalamazoo River would lead to a reduction in FCAs in the Lake Michigan area affected by PCBs contamination from the Kalamazoo River. This is remotely possible, but unlikely.

Table 2.14. Present value (in 2003) of future recreational fishing damages starting in 2003 (expressed as 2001\$) (cont.)

	Quality losses (millions)	Reduced fishing days losses (millions)	Total damages (millions)
Kalamazoo River and Lake Michigan			
Future damages with no cleanup (2003-2102)	\$5.7 to \$6.3	\$2.0 to \$4.5	\$7.6 to \$10.9
Future damages with intermediate cleanup (2003-2042)	\$3.8 to \$4.2	\$1.4 to \$3.2	\$5.1 to \$7.4
Future damages with intensive cleanup (2003-2022)	\$2.7 to \$3.0	\$0.9 to \$2.1	\$3.6 to \$5.1

The present values of all damages (past, present, and future; in 2003) are shown in Table 2.15. Total damages are estimated to be between \$17.1 to \$30.7 million with no action, \$14.6 to \$27.3 million with intermediate cleanup, and \$13.0 to \$24.9 million with intensive cleanup.

Table 2.15. Present value (in 2003) of total (past and future) recreational fishing damages from 1981 forward (expressed as 2001\$)

	Quality losses (millions)	Reduced fishing days losses (millions)	Total damages (millions)
Kalamazoo River			
Total damages with no cleanup (1981-2102)	\$6.3 to \$6.6	\$3.1 to \$11.5	\$9.4 to \$18.1
Total damages with intermediate cleanup (1981-2042)	\$5.2 to \$5.5	\$2.8 to \$10.5	\$8.0 to \$15.9
Total damages with intensive cleanup (1981-2022)	\$4.5 to \$4.8	\$2.6 to \$9.7	\$7.1 to \$14.5
Lake Michigan			
Total damages with no cleanup (1981-2102)	\$4.0 to \$6.1	\$3.6 to \$6.5	\$7.6 to \$12.6
Total damages with intermediate cleanup (1981-2042)	\$3.2 to \$5.2	\$3.3 to \$6.2	\$6.6 to \$11.3
Total damages with intensive cleanup (1981-2022)	\$2.8 to \$4.6	\$3.1 to \$5.8	\$5.9 to \$10.4
Kalamazoo River and Lake Michigan			
Total damages with no cleanup (1981-2102)	\$10.3 to \$12.8	\$6.8 to \$17.9	\$17.1 to \$30.7
Total damages with intermediate cleanup (1981-2042)	\$8.4 to \$10.7	\$6.2 to \$16.6	\$14.6 to \$27.3
Total damages with intensive cleanup (1981-2022)	\$7.3 to \$9.4	\$5.7 to \$15.5	\$13.0 to \$24.9